

## Review of Chepstow-Lust et al.

### General Comments

Overall, this manuscript takes interesting paleoclimatic data and attempts to synthesize them with emerging archaeological perspectives on the rise of the Inka empire. In this review, I comment not on the technical aspects of the core analysis (which are not my expertise), but on the strength of the synthesis of environmental results with archaeological perspectives. What is very good about the present work is that the data are used to view major cultural changes in the Andean region as occurring within a context of significant shifts in temperature and precipitation. The treatment of archaeological data could be stronger, and the argument should be reoriented to account for changing human settlement patterns, population levels, and subsistence strategies over time. Given that archaeologists have been slow in moving toward a synthesis that addresses a nuanced human-environment dynamic, it is perhaps unfair to take the climate scientists to task too much on this. There are some very smart things being done with the paleoclimate data in this paper, but I urge interpretive caution and greater clarity. Finally, I strongly recommend that the authors rethink the “green” interpretation of Inka environmental stewardship, and focus on the Malthusian effects (demographic, as well as in terms of environmental impacts) of resource intensification and imperial expansion.

### Specific Comments

**Introduction:** The ecology of human resource management as characterized in this introduction seems simplistic: environments present challenges for human subsistence, and humans adapt to the new limitations imposed on them. This misses some essential aspects of human ecology, namely that the arc of human population growth (crudely figured in terms of carrying capacity) occurs in fluctuating environments, so that subsistence strategies may be both adaptive and innovative; and human population growth and subsistence intensification involve environmental impacts that will vary across regional resource mosaics and population patterns. If one assumes that (1) early human population levels fell well below carrying capacity, (2) cultural mechanisms (intensification, storage, social networks, exchange activities) can be employed to reduce risks and average out resource availability over time, and (3) the catchment area for early village networks (in terms of fields, pasture areas, hunting grounds, and areas for collecting wild resources) would cover a fairly sizeable region, reading the climatic data becomes a much more complex question. In introducing the adaptive nature of Andean peoples, the authors observe that humans developed intensive agricultural works in highly arid environments (such as Nasca), but then they turn to the central highlands and seemingly presume that such constructions and productive practices were not possible until Inka times.

p. 3: “The Inca of the south-central Andes were particularly successful in developing sustainable

landscape practices.” I have seen the scant literature alleging the sustainability of Inka practices, which ignores the assertions of frequent crop failure in many Inka provincial regions, as well as the fact that the Cusco region was so thoroughly deforested in Inka imperial times that emperors placed guards over stands of trees that remained, a practice that continued in the first years of the Spanish colonial system. To my knowledge, the assertions of Inka green farming are not founded in hard data, but are merely wishful portrayals of non-Western empires as somehow possessing the secret of how to mobilize highly extractive and intensive economies and stimulate massive population growth with no deleterious environmental effects. This should not be accepted without hard evidence.

p. 4: “It is widely suggested that their decline was accelerated by worsening environmental conditions that decreased opportunities for agrarian intensification in the south-central Andes at that time (Williams, 2001, 2002, 2006).” First, the citation of Williams’ research at Cerro Baúl does not reflect a widespread consensus on the Wari decline—there is virtually nothing published on the Wari decline in the imperial heartland or other provincial regions. The results from Cerro Baúl—located in the south Peruvian coastal desert in an upper valley region—should not be considered typical for other areas of Wari settlement. Williams suggests that Cerro Baúl survived the collapse of both Wari and Tiwanaku, maintaining its central organization until around AD 1050 (by comparison, the abandonment of the Wari site of Pikillacta in the Cusco region is thought to have occurred around AD 900). After this time, hydraulic agriculture may still have been capable of sustaining significant population levels in the Osmore Valley, but the lack of social integration encouraged more localized canal systems that were easier to build and maintain (and from an evaporation perspective, more efficient).

The same may be true for the Cusco region, where the areas most intensively settled by Wari continued to have large valley-bottom communities (like Chokepukio, Cotocotuyoc, and Minaspata) whose economies were presumably based on hydraulic agriculture. The Middle Horizon villages of the Cusco Basin tend to have continuous settlement after AD 1000, and in many cases, into Inka times. While there is certainly evidence of environmental changes beginning in the last century or so of the first millennium, the hard evidence that aridity was severe and sustained enough to make hydraulic agriculture impossible throughout the central Andean highlands is perhaps too broad a stance to assume. At the local level of the Patakanca Valley, it is possible that fluctuating climatic conditions would render hydraulic agriculture an unreliable subsistence strategy after AD 1000, but that does not mean that the valley became economically useless. In the Titicaca Basin, the same processes did not lead to abandonment of the region, but rather a change in subsistence strategies to shifting horticultural production with a herding component.

pp. 4-5: The coring work and analysis conducted at Marcacocha is indeed valuable, but whether it can be extrapolated onto the archaeological patterns of the Cusco region as a whole is another question. The lake is located in the upper part of a small side valley of the Urubamba River, at the far edge of what the Inkas considered to be their imperial heartland. It is located mid-way up the valley en route to an important pass down into an area where Inka rulers had coca plantations; but the economic focus of the region (at least in Inka times) was the valley-bottom maize lands located several hundred meters lower, at the confluence with the Urubamba River. The environmental characteristics of small transverse valleys of the Vilcanota-Urubamba Valley vary substantially, and their settlement histories are different from the larger valley areas located to the south, where the Inka capital of Cusco is located.

## **Interpretation and Discussion**

The preceding observation—that Marcacocha may reflect the human transformation of a very specific and localized environment over time—raises some problems with the interpretation of research results.

p. 9: “*Chenopodiaceae* pollen, which probably includes a number of cultivars such as *Chenopodium quinoa*, is rare (Chepstow-Lusty et al., 2003), suggesting suppressed, cool temperatures over this period.” If this pollen reflects domesticated plants introduced to the area intentionally by humans, then the paucity of such pollen would seem to reflect low human population densities, or a focus on other kinds of subsistence strategies (and not climatic conditions). Archaeological settlement patterns throughout the Andean highlands (including the Cusco region) suggest that population levels in the Early Horizon and Early Intermediate Period were only a fraction of what they were in Inka times, and large early villages (c. 800 BC-AD 300) in the Cusco region are found near valley-bottom agricultural lands, as well as in higher elevation areas where mixed horticulture and herding could be carried out effectively. Early villages in the Cusco region are not restricted to lower elevations, but there is a considerable settlement shift after c. AD 300 or so in many parts of the region (especially the Vilcanota-Urubamba Valley) reflecting a preference for lower elevation farming locations and a more dispersed settlement pattern (Bauer 2004; Covey 2006). The brief description of pre-AD 880 conditions cannot account for the regional variation and temporal dynamics of human landscape used known in the archaeological record. Steven Kosiba’s dissertation research should clarify some of the localized archaeological settlement patterns for this area.

p. 10: I’m not sure how macrocharcoal levels can be taken as evidence of either agriculture or herding activities. Locals in Cusco do set fires to field stubble at lower elevations, but fires are also frequently set in *puna* grasslands that tend to burn much greater areas. The authors need to provide a convincing argument regarding why macrocharcoal can be taken as an indicator of a particular subsistence activity (agriculture and not herding), and not some other cause, such as lightning or human domestic habitation.

p. 10: The authors seem to treat agriculture and herding as alternatives rather than elements of a single local or regional economy—high macrocharcoal and low mite density is seen as evidence of the former, while low macrocharcoal and high mite density is considered to reflect a shift to the latter. In fact, the economies of the mid- and upper valley areas in this region were probably mixed, and camelids would be expected not just among herders, but maintained by agricultural groups to bring harvests in from the fields and to manage caravan activities between valleys. One problem with Marcacocha is that it is not the best location for agriculture (the valley bottom near Ollantaytambo has permanent water and is low enough not to experience frost), but it is also not necessarily the best place for herding, which tends to take place in higher elevation areas with the bofedal and grass resources preferred by llamas and alpacas. I am not unconvinced that an uptick in mite densities could reflect more camelids in the Marcacocha area, but whether that is evidence of climate change, increased population density, broadened local subsistence strategies, or increased caravan activity is less clear.

p. 12: In the post-1532 discussion macrocharcoal is now taken as evidence of burning associated with pasturing European animals—this change in interpretation needs to square with known practices, as well as with the earlier assertions that macrocharcoal is linked to agricultural activity. Also, what is the evidence that European animals only begin to be brought to the region around 1600? There are ample references to cows, chickens, pigs, and sheep in sixteenth century documents, but perhaps a local shift from Andean camelids to European animals in this particular area took more time? In many highland areas, early Spaniards found that their animals did not thrive immediately at high elevation. There are definitely references to European sheep and cows being kept in the region by the last decades of the sixteenth century, but not necessarily by native communities.

p. 15: Seeking a broader context for the Marcacocha data is important, but this should include tighter control over the archaeological record. Kosiba's (PhD 2009, University of Chicago) recent survey of the Patakanca Valley should provide a temporal treatment of human occupation, which should in turn be placed in the context of other regional projects completed by Bauer, Covey, Kendall, and others. The rise of population in the Marcacocha area around AD 1000 is not part of a state expansion by any group, but rather reflects a tendency in the Vilcanota-Urubamba Valley (and many other nearby highland regions) for populations to seek mosaic agropastoral environments in the mid- and upper valley areas. The settlement systems and economies that led to Inka state expansion around AD 1250-1300 contrast with this pattern—the Inkas were intensive maize cultivators who lived in large valley-bottom settlements.

### **Technical Corrections**

p. 3: "While the factors involved in their sudden collapse under the stress of the Spanish invasion, the introduction of new diseases and civil wars have been well documented (Hemming, 1970), relatively little scholarly attention has been focused on their rapid rise as a pan-Andean power." This sentence is unclear as written.